Ocean Heat Storage and Net Radiation: Cooling?

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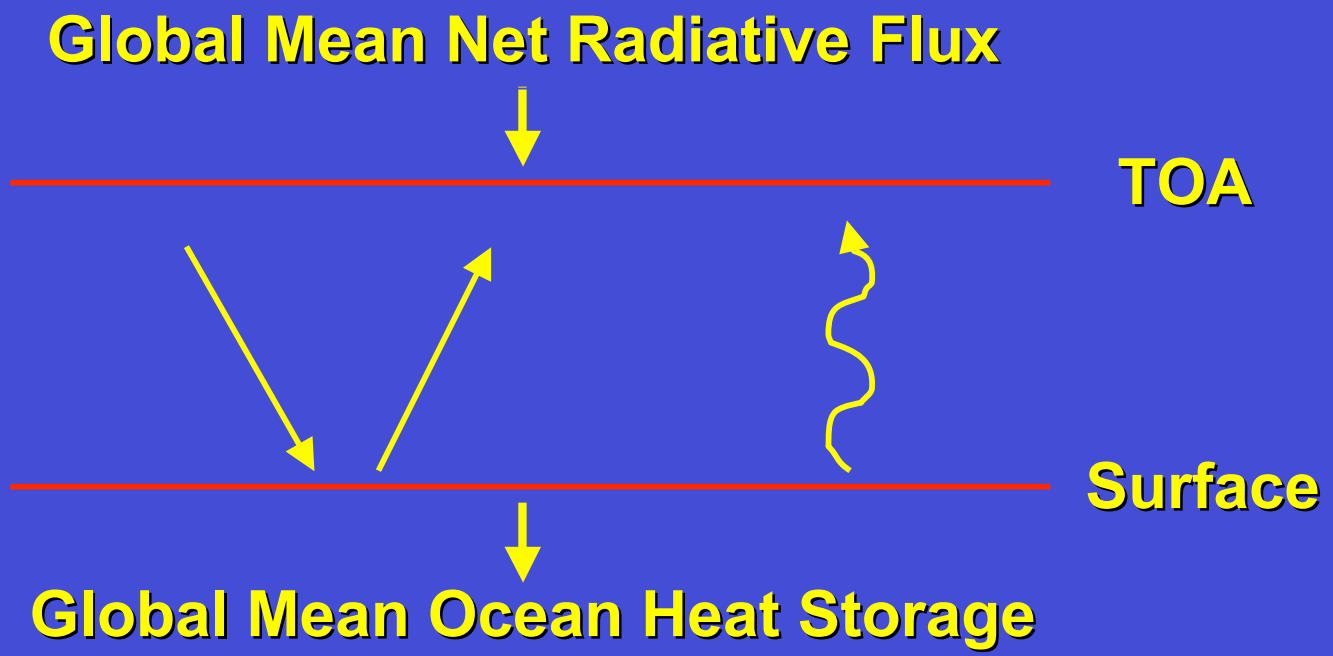
Goals

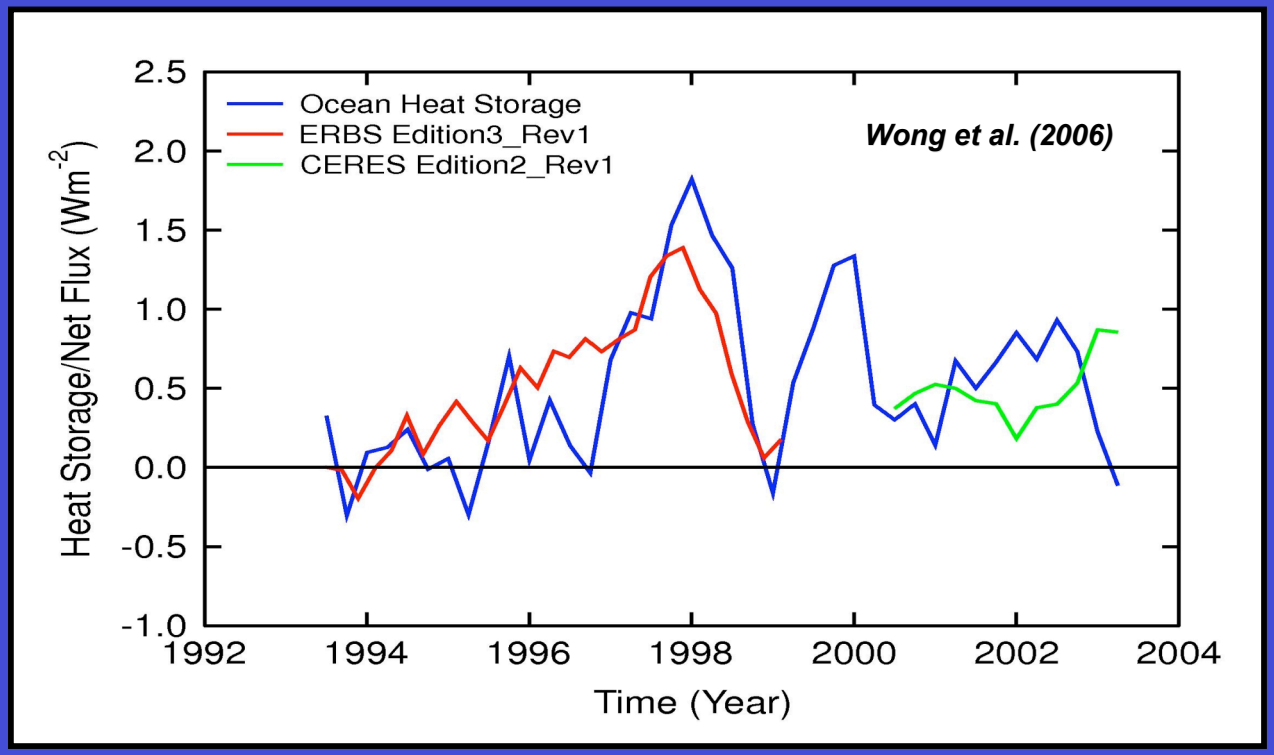
- Review previous comparison between ocean heat storage and top of atmosphere (TOA) net radiation from ERBS nonscanner and CERES scanner data
- Look at consistency between the latest ocean heat content anomalies (cooling after 2003) and CERES TOA net radiation

TOA Net Radiation and Ocean Heat Storage



- Over the long-time average (I.e., year and longer), the global Net radiation at TOA should be in phase with and of the similar magnitude to global ocean heat storage since other storage terms in the Earth climate system are factors of 10 or more smaller than ocean heat storage (Levitus, 2001)

Previous Comparison (1993 to 2003)

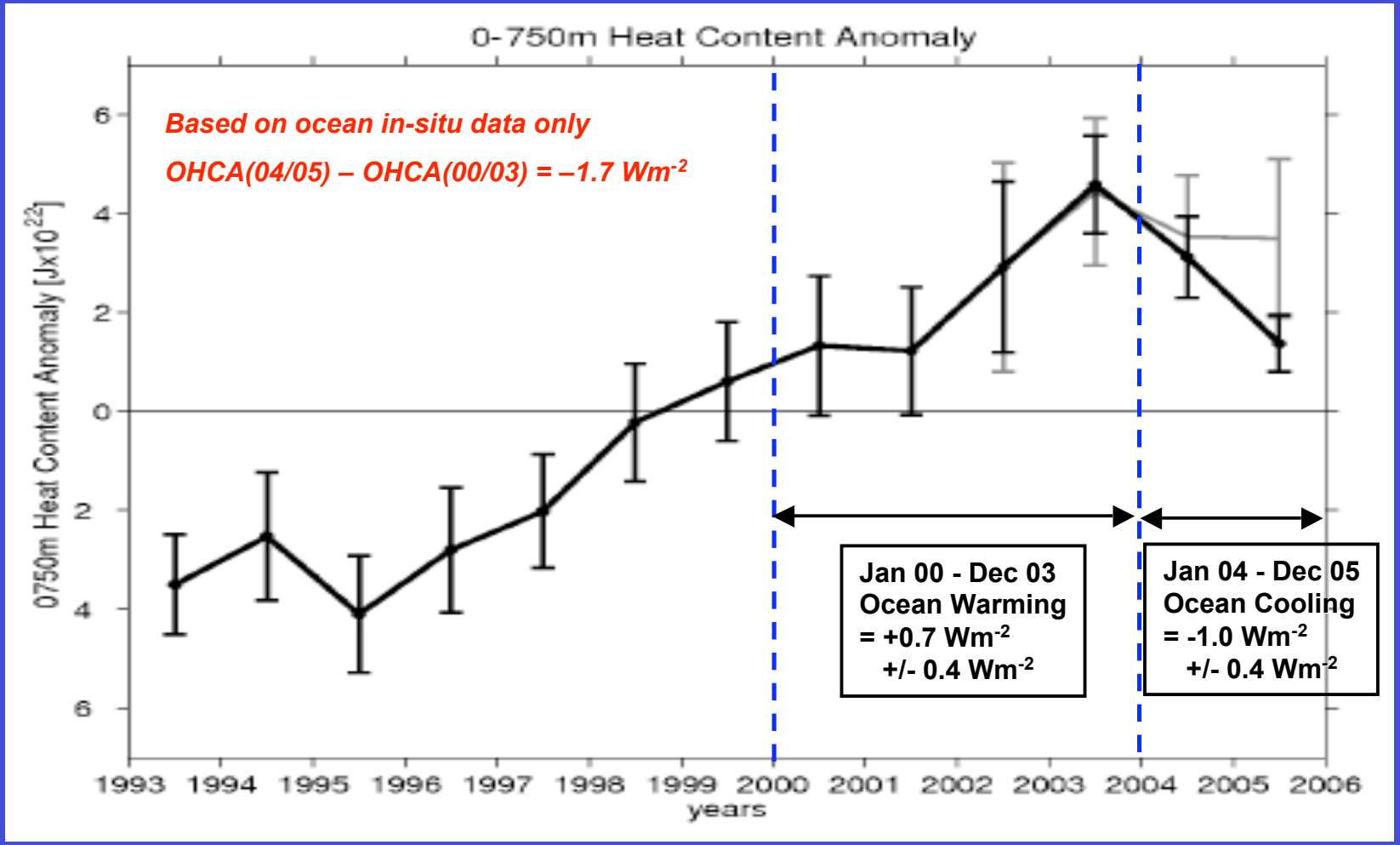


- Interannual net flux anomalies from ERBS and CERES agree within ocean heat storage sampling uncertainties (1 sigma of 0.4 Wm^{-2})
- The net flux anomalies within a single decade can be as large as 1.5 Wm^{-2} and are due, most likely, to changes in cloudiness

New Comparison

- Recent ocean heat content results (Lyman et al., GRL, Aug 2006) suggest large ocean cooling after 2003
- Is this cooling consistent with CERES net radiation data?

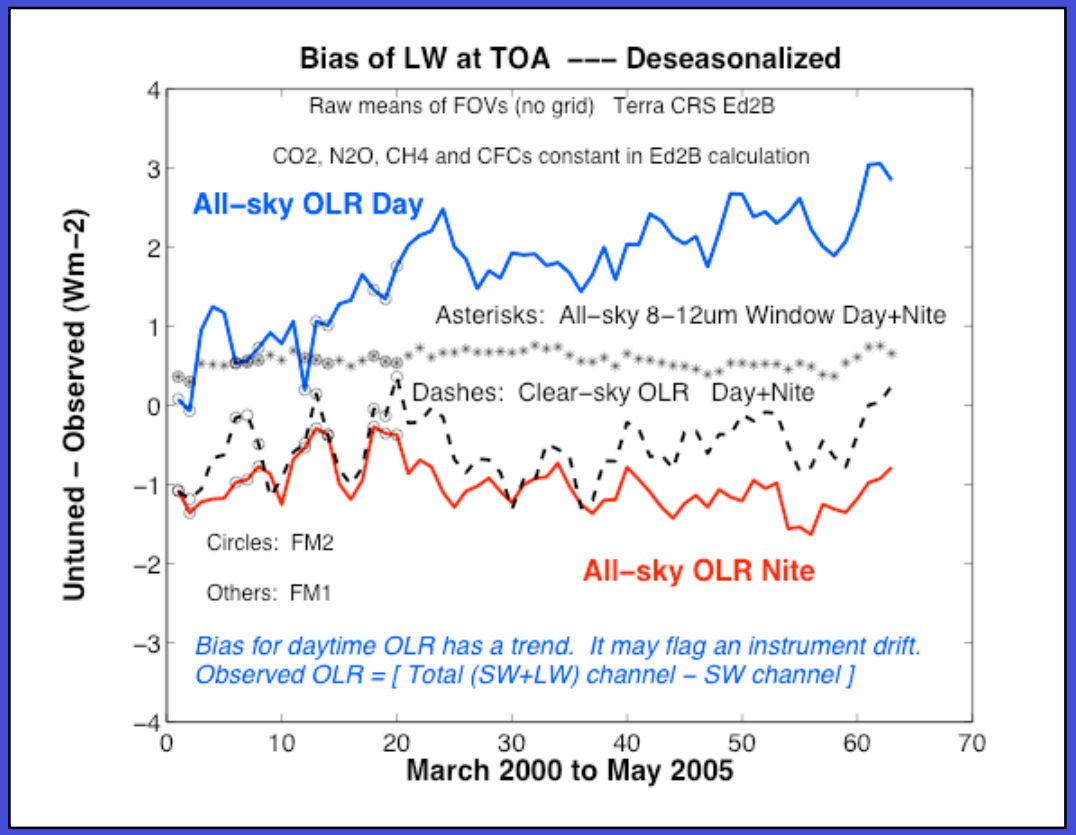
Lyman et al., 2006 Ocean Cooling in 2004/2005



Note: Change in OHCA of 1x10^{22} J per year = 0.6 Wm^{-2}

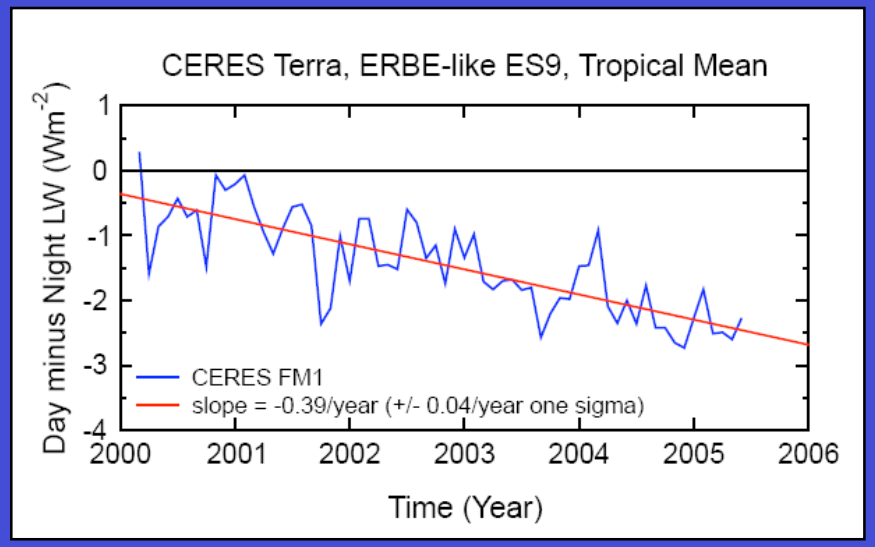
Lyman et al., GRL, Aug 2006

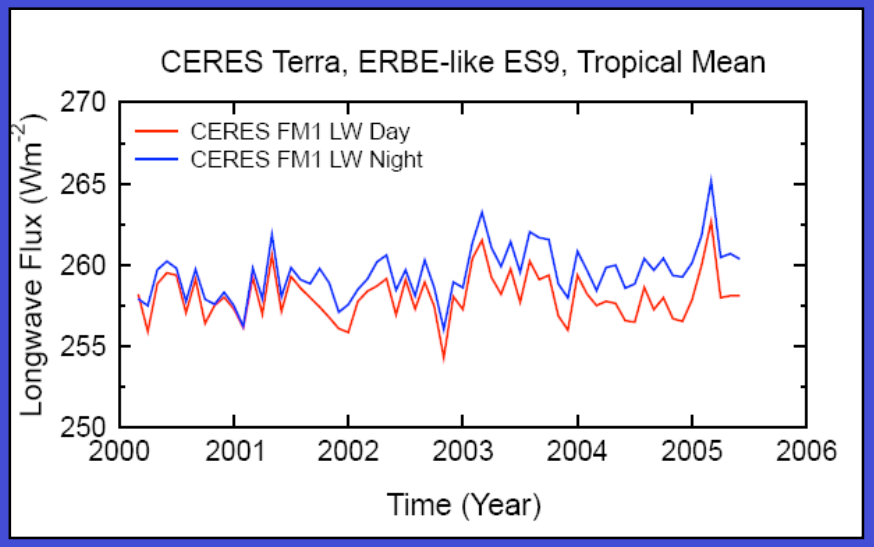
Terra Ed2_Rev1 + Daytime LW Correction



- CERES CRS daytime LW untuned minus observed time series indicates a problem with Terra observed daytime LW flux with time; increasing by 0.38 Wm^{-2} per year; observations are too low

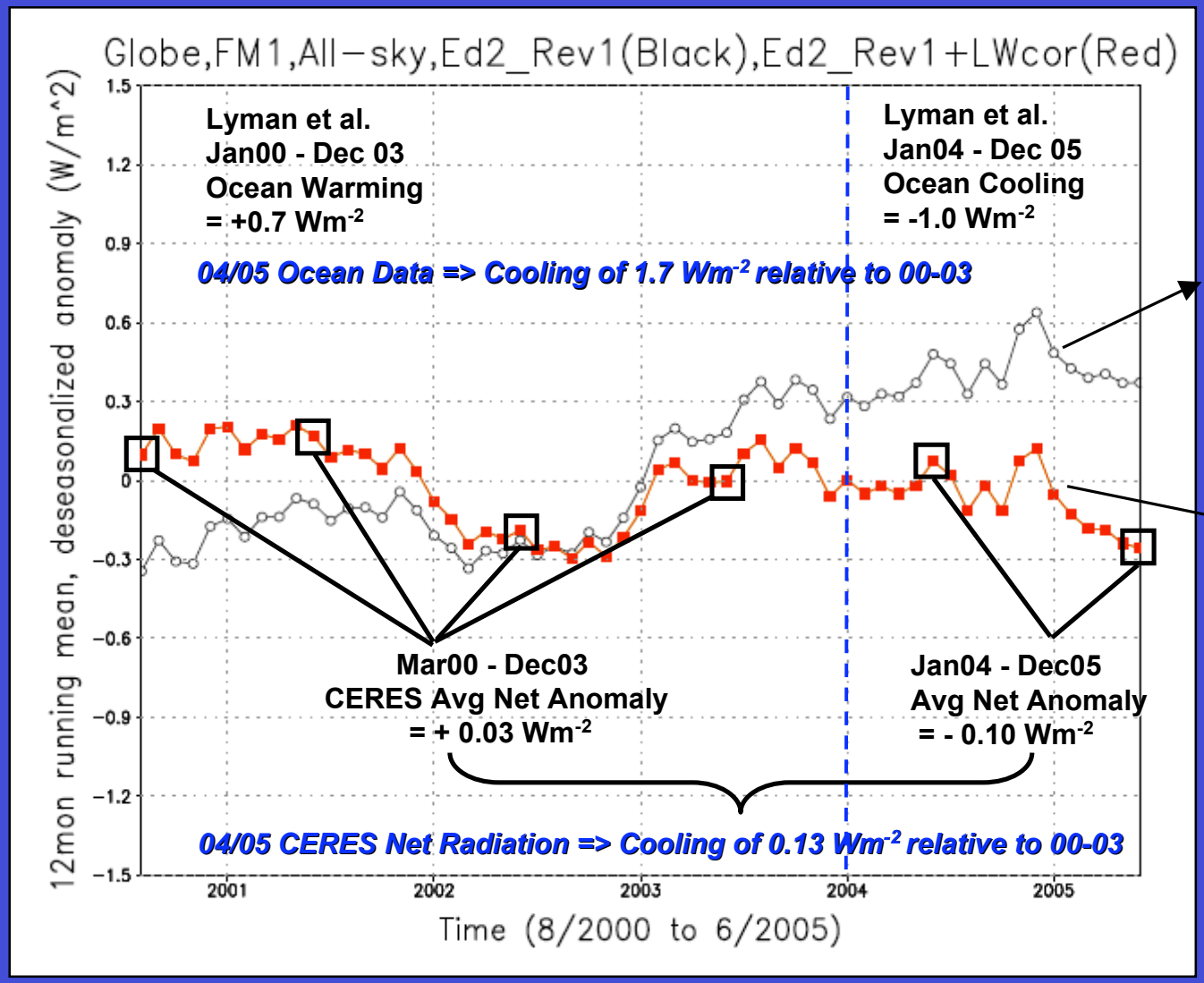
Terra Ed2_Rev1 + Daytime LW Correction (cont.)





- ERBE-like also see a similar signal in the day minus night LW difference time series
- A quick daytime LW correction is developed using the global mean CERES CRS daytime LW untuned minus observed time series and applied to the Edition2_Rev1 global mean LW data

Does CERES Net Radiation Indicate Recent Ocean Cooling?



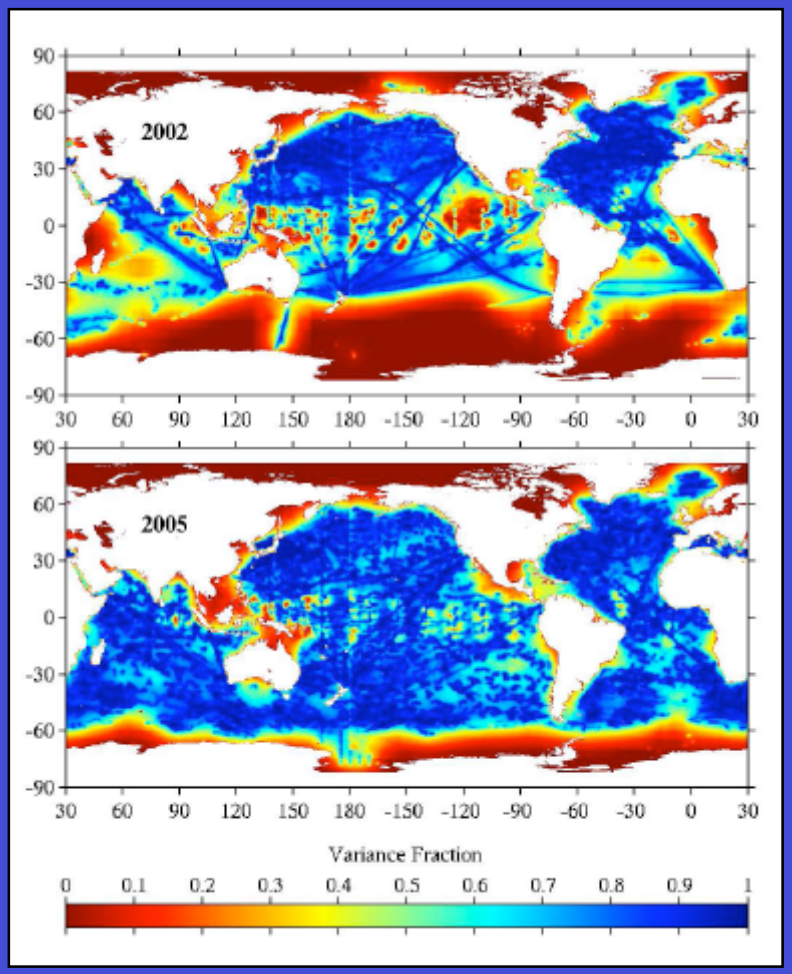
Global Net CERES Terra FM1 Instrument ES-8 All-Sky TOA Flux Edition 2, Rev1 12 mo running means (June = year center) current data (Wong)

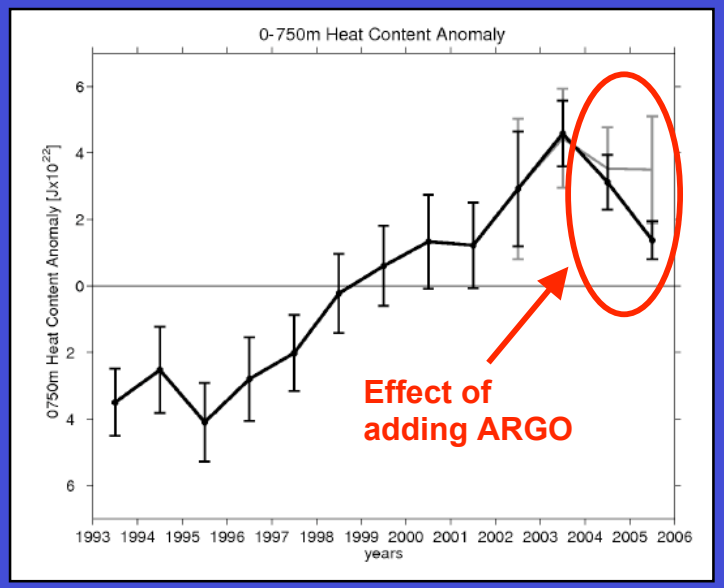
Same as above, but showing the level of changes expected in Edition 3 calibration improvements, primarily in daytime LW fluxes (Wong, Charlock, Mathews, Priestley, Loeb)

What are the current key uncertainties?

- **CERES Net Radiation**
  - CERES Edition2 Rev 1 corrected SW fluxes for in-orbit contamination, but effect on daytime LW in future Edition 3: impact magnitude estimated in previous chart (red vs. black)
  - CERES instrument stability at better than 0.5 Wm^{-2} design level is still being independently validated
  - OHCA signal is change in ocean heating of -1.7 Wm^{-2} global mean 04-05 minus 00-03
  - GEWEX Radiative Flux Assessment underway: surface radiometer comparisons, ~ 40 sites, 12-mo avg anomalies: 0.3 Wm^{-2} SW, 1.0 Wm^{-2} LW
- **Ocean Heat Storage**
  - heat in ocean below 750m depth not included
  - heat in the ocean beneath sea ice not included
  - tide gauges and altimeter show sea level continues to rise despite 0-750m cooling (i.e. thermal contraction)
  - glacial ice melting faster but is it fast enough to compensate for change in thermal expansion? key is GRACE data on ice mass loss
  - ARGO now nearly complete: future data observes in situ ocean heat storage to 1000 - 2000m depths.

Ocean Heat Content Sampling Issues





- Large changes of in-situ spatial sampling
- Calibration consistency between instruments with time

Conclusions

- Ocean heat content anomaly cooling in 2004 and 2005 exceeds space/time sampling noise estimates for 0-750m depths by a factor of 3 (1.7 vs. sqrt(0.4^2 + 0.4^2) = 0.56 Wm^{-2})
- Net Radiation changes in CERES (Ed3) is expected to show ***CERES at - 0.1 Wm^{-2} vs. Ocean data of -1.7 Wm^{-2}***
- GRACE data show no accelerated glacial ice mass loss in 2004/2005 relative to 2000/2003; glacial ice mass loss can't explain the recent ocean water contraction (cooling)
- Ocean altimeter is also critical for determining total sea level change in 2004/2005 to close the ocean water budget
- Altimeter / GRACE / Ocean In-Situ / CERES all needed to close the balance and verify cause/effect and rule out remaining uncertainties

CERES CRS Surface Flux Anomalies vs. Surface Radiometers